CLAIMS

1. A detector arrangement for detection of radiation comprising:

- a chamber adapted to be filled with an ionizable and scintillating substance;

- a radiation entrance arranged such that radiation can enter said chamber partly for ionizing said ionizable and scintillating substance, partly for being converted into light therein;

- a light detection arrangement for temporally and spatially resolved detection of some of said light;

- an electron avalanche detection arrangement for avalanche amplification of electrons released as a result of said ionization of said ionizable and scintillating substance, and for temporally and spatially resolved detection of said avalanche amplified electrons;

- correlating means for correlating detected light and detected avalanche amplified electrons, which are derivable from a single radiation photon; and

- producing means for producing a single signal from said correlated detected light and detected avalanche amplified electrons.

2. The detector arrangement as claimed in claim 1 wherein said ionizable and scintillating substance is in liquid phase.

3. The detector arrangement as claimed in claim 1 wherein said ionizable and scintillating substance is in gas phase.

4. The detector arrangement as claimed in claim 3 wherein said gaseous substance has a pressure above atmospheric pressure.

5. The detector arrangement as claimed in claim 1 wherein said ionizable and scintillating substance is in solid phase.

~~6. The detector arrangement as claimed in claim 1 wherein said substance is a scintillating medium, optionally mixed with a medium for enhanced avalanche multiplication.~~

~~7. The detector arrangement as claimed in claim 6 wherein said scintillating medium is any of Ar, Xe, Kr, or a mixture thereof, and said medium for enhanced avalanche multiplication is CO_2, CH_4, C_2H_6, isobuthane, or a mixture thereof.~~

8. The detector arrangement as claimed in claim 1 wherein said light detection arrangement is oriented to detect light emitted mainly perpendicular to said radiation entered into said chamber.

9. The detector arrangement as claimed in claim 8 wherein said chamber is divided into a plurality of radiation absorption volumes separated by light reflecting or absorbing walls, each of said walls being substantially parallel with the radiation entered into said chamber.

10. The detector arrangement as claimed in claim 1 wherein said light detection arrangement includes a plurality of light collimators arranged in an array.

11. The detector arrangement as claimed in claim 1 wherein said light detection arrangement comprises a photomultiplier tube for said temporally and spatially resolved detection of light.

~~12. The detector arrangement as claimed in claim 1 wherein said light detection arrangement comprises a solid-state based detector, particularly a CCD-based detector, for said temporally and spatially resolved detection of said light.~~

13. The detector arrangement as claimed in claim 12 wherein said solid-state based detector includes a plurality of individual

light detection elements arranged in an array such that each light detection element is capable of detecting light derivable from absorption by a respective transversely separated portion of said radiation entered into the chamber.

14. The detector arrangement as claimed in claim 1 wherein said light detection arrangement comprises:

- a photocathode adapted to release photoelectrons in dependence on said light;

- an electron avalanche amplifier adapted to avalanche amplify said photoelectrons; and

- a readout arrangement adapted to detect said avalanche amplified electrons.

15. The detector arrangement as claimed in claim 14 wherein said readout arrangement includes a plurality of readout elements arranged in an array such that each readout element is capable of detecting avalanche amplified electrons derivable from absorption by a respective transversely separated portion of said radiation entered into the chamber.

16. The detector arrangement as claimed in claim 1 wherein said electron avalanche detection arrangement comprises:

- a cathode and an anode, between which an electrical field can be applied for drift of said electrons released as a result of said ionization;

- an electric field concentration means arranged between said cathode and said anode for acceleration and said avalanche amplification of said released electrons; and

- a readout arrangement for said temporally and spatially resolved detection of said avalanche amplified electrons.

17. The detector arrangement as claimed in claim 16 wherein said readout arrangement comprises a plurality of readout elements arranged in an array such that each readout element is capable of detecting avalanche amplified electrons derivable from absorption by a respective transversely separated portion of said radiation entered into the chamber.

18. The detector arrangement as claimed in claim 17 wherein said electric field concentration means includes an electrode provided with a plurality of apertures to allow electrons to pass through said electrode.

19. The detector arrangement as claimed in claim 1 wherein

- said light detection arrangement is adapted for energy resolved detection of light; and

- said producing means is adapted to produce said single signal in dependence on the energy of said correlated detected light.

20. The detector arrangement as claimed in claim 19 wherein said single signal has spatial and temporal resolutions comparable to the spatial and temporal resolutions of the detected avalanche amplified electrons, and a spectral resolution comparable to the spectral resolution of the detected light.

21. A positron emission tomography apparatus for construction of a three-dimensional image of an object from linear projections of radiation as emitted from the object comprising the detector arrangement as claimed in claim 1 for detection of the radiation as emitted from said object.

22. A method for detection of radiation comprising the steps of:

- entering radiation into a chamber filled with an ionizable and scintillating substance partly for ionizing said ionizable and

scintillating substance, partly for converting radiation into light therein;

- detecting at least some of said light temporally and spatially resolved by means of a light detection arrangement;

- avalanche amplifying electrons released as a result of said ionization of said ionizable and scintillating substance, and detecting said avalanche amplified electrons temporally and spatially resolved by means of an electron avalanche detection arrangement;

- correlating detected light and detected avalanche amplified electrons, which are derivable from a single radiation photon; and

- producing a signal from said correlated detected light and detected avalanche amplified electrons.

23. The method as claimed in claim 22 wherein said at least some of said light is detected substantially perpendicular to said radiation entered into said chamber.

24. The method as claimed in claim 22 wherein light derivable from absorption by a respective one of a plurality of transversely separated portions of said radiation entered into said chamber is separately detected by means of a plurality of individual light detection elements arranged in an array.

25. The method as claimed in claim 22 wherein said temporally and spatially resolved detection of at least some of said light is performed by the steps of:

- releasing photoelectrons in dependence on said light by means of a photocathode;

- avalanche amplifying said photoelectrons by means of an electron avalanche amplifier; and

- detecting said avalanche amplified electrons by means of a readout arrangement.

26. The method as claimed in claim 22 wherein avalanche amplified electrons derivable from absorption by a respective one of a plurality of transversely separated portions of said radiation entered into said chamber are separately detected by means of a plurality of individual detection elements arranged in an array.

27. The method as claimed in claim 22 wherein

- said at least some of said light is detected spectrally resolved by means of a light detection arrangement; and

- said signal produced from said correlated detected light and detected avalanche amplified electrons is produced in dependence on the spectral information of said correlated detected light.

28. The method as claimed in claim 27 wherein said signal produced from said correlated detected light and detected avalanche amplified electrons is produced to have spatial and temporal resolutions comparable to the spatial and temporal resolutions of the detected avalanche amplified electrons, and to have a spectral resolution comparable to the spectral resolution of the detected light.

29. A positron emission tomography method for construction of a three-dimensional image of an object from linear projections of radiation as emitted from the object wherein said radiation as emitted from the object is detected according to the method as claimed in claim 22.

30. A positron emission tomography (PET) apparatus for construction of an image of an object containing positron emitting substance, said apparatus comprising:

- a detector arrangement including:

- a chamber adapted to be filled with an ionizable substance;

- a radiation entrance arranged such that gamma radiation photon pairs emitted in dependence on said positrons can enter said chamber for ionizing said ionizable and scintillating substance;

- an electron avalanche detection arrangement for avalanche amplification of electrons released as a result of said ionization of said ionizable substance, and for temporally and spatially resolved detection of said electron avalanches;

- a processing means coupled to said detector arrangement, said processing means including:

- means for matching a pair of detected electron avalanches, which are derivable from a single radiation photon pair;

- means for producing a signal from said matched electron avalanche pair;

- said means for matching being arranged to repeat the matching for each further detected electron avalanche, and said means for producing being arranged to repeat the producing of a respective signal for each further matched electron avalanche pair; and

- reconstruction means for performing a reconstruction process based upon said respective signals as produced by said means for producing, wherein said reconstruction means calculates amounts of emitted positrons from each of an arbitrarily large number of image volumes selected within said object; and

- a display unit coupled to said processing means for projecting an image of said amounts of emitted radiation.

31. The positron emission tomography apparatus as claimed in claim 30 wherein:

- said chamber is adapted to be filled with a scintillating substance;

- said radiation entrance is arranged such that gamma radiation photon pairs emitted in dependence on said positrons can enter said chamber for being converted into light therein;

- said detector arrangement further includes a light detection arrangement for temporally and spatially resolved detection of at least some of said light;

- said means for matching a pair of detected electron avalanches derivable from a single radiation photon pair, is further adapted to match detected light derivable from said single radiation photon pair; to correlate the matched avalanche electron pair and the matched light, which are derivable from the single radiation photon pair; to repeat the matching of detected light for each further detected light; and to repeat the correlating of matched avalanche electrons and matched light derivable from a single radiation photon pair for each further matched electron avalanche pair and each further matched light; and

- said producing means is adapted to produce a single signal from said correlated detected electron avalanche pair and detected light; and to repeat the producing of a respective signal for each further correlated matched electron avalanche pair and matched light.

32. The positron emission tomography apparatus as claimed in claim 31 wherein

- said light detection arrangement is adapted for energy resolved detection of light; and

- said producing means is adapted to produce each respective signal in dependence on the energy of the corresponding respective correlated detected light.

33. The positron emission tomography apparatus as claimed in claim 32 wherein each respective signal has spatial and temporal resolutions comparable to the spatial and temporal resolutions of the respective detected avalanche amplified electrons, and a spectral resolution comparable to the spectral resolution of the respective detected light.

34. A positron emission tomography (PET) method for construction of an image of an object containing positron emitting substance, comprising the steps of:

- entering gamma radiation photon pairs emitted in dependence on said positrons into a chamber filled with an ionizable substance;

- avalanche amplifying electrons released as a result of said ionization of said ionizable substance and detecting said electron avalanches temporally and spatially resolved by means of an electron avalanche detection arrangement;

- matching a pair of detected electron avalanches, which are derivable from a single radiation photon pair;

- producing a signal from said matched electron avalanche pair;

- repeating the step of matching for each further detected electron avalanche;

- repeating the step of producing a signal for each further matched electron avalanche pair;

- performing a reconstruction process based upon said signals as produced, wherein amounts of emitted positrons from each of an arbitrarily large number of image volumes selected within said object are calculated; and

- projecting an image of said amounts of emitted radiation.

35. The positron emission tomography method as claimed in claim 34 wherein:

- said ionizable substance is also scintillating such that said gamma radiation photon pairs emitted in dependence on said positrons can be converted into light therein;

- at least some of said light is detected temporally and spatially resolved by means of a light detection arrangement;

- the step of matching includes matching of detected light derivable from a single radiation photon pair, which matching of detected light is repeated for each further detected light;

- the matched avalanche electron pair and the matched light derivable from a single radiation photon pair are correlated, which correlation is repeated for each further matched electron avalanche pair and for each further matched light; and

- the respective signal as produced in the step of producing is produced from the respective correlated detected electron avalanche pair and detected light.

36. The positron emission tomography method as claimed in claim 35 wherein

- light is detected energy resolved by means of said light detection arrangement; and

- each respective signal is produced in dependence on the energy of the corresponding respective correlated detected light.

37. The positron emission tomography method as claimed in claim 36 wherein each respective signal has spatial and temporal resolutions comparable to the spatial and temporal resolutions of the respective detected avalanche amplified electrons, and a spectral resolution comparable to the spectral resolution of the respective detected light.

38. A detector arrangement for detection of radiation comprising a cathode and an anode between which a voltage is applied, said arrangement comprising:

- a chamber arranged at least partially between said cathode and said anode, said chamber being filled with an ionizable and scintillating substance;

- a radiation entrance arranged such that radiation can enter said chamber between and substantially parallel with said cathode and said anode, partly for being converted into light therein, partly for ionizing said ionizable and scintillating substance, whereby electrons released as a result of said ionization of said ionizable and scintillating substance are drifted substantially perpendicular to the direction of said entered radiation by means of said applied voltage;

- a light detection arrangement for temporally and spatially resolved detection of at least some of said light;

- an electron avalanche detection arrangement for avalanche amplification of said drifted electrons, and for temporally and spatially resolved detection of said avalanche amplified electrons, said electron avalanche detection arrangement being oriented such that said drifted electrons are accelerated, during avalanche amplification, in a direction substantially perpendicular to the direction of said entered radiation;

- correlating means for correlating detected light and detected avalanche amplified electrons, which are derivable from a single radiation photon; and

- producing means for producing a single signal from said correlated detected light and detected avalanche amplified electrons.

39. The detector arrangement as claimed in claim 38 wherein

- said light detection arrangement is adapted for energy resolved detection of light; and

- said producing means is adapted to produce said single signal in dependence on the energy of said correlated detected light.

40. The detector arrangement as claimed in claim 39 wherein

- said radiation entrance is formed to allow said radiation to be a planar radiation beam;

- said electron avalanche detection arrangement includes a plurality of readout elements arranged in an array such that each readout element is capable of detecting avalanche amplified electrons derivable from absorption by a respective transversely separated portion of said radiation entered into the chamber; and

- said light detection arrangement includes a plurality of individual light detection elements arranged in an array such that each light detection element is capable of detecting light derivable from absorption by a respective transversely separated portion of said radiation entered into the chamber.

41. A method for detection of radiation comprising the steps of:

- entering radiation into a chamber filled with an ionizable and scintillating substance partly for ionizing said ionizable and

scintillating substance, partly for converting radiation into light therein;

- detecting at least some of said light temporally and spatially resolved by means of a light detection arrangement;

- drifting electrons released as a result of said ionization of said ionizable and scintillating substance in a direction substantially perpendicular to the direction of said entered radiation by means of applying an electrical field within said chamber;

- avalanche amplifying drifted electrons through acceleration of said drifted electrons in a direction substantially perpendicular to the direction of said entered radiation by means of applying an electrical field within said chamber;

- detecting said avalanche amplified electrons temporally and spatially resolved by means of an electron avalanche detection arrangement;

- correlating detected light and detected avalanche amplified electrons, which are derivable from a single radiation photon; and

- producing a signal from said correlated detected light and detected avalanche amplified electrons.

42. The method as claimed in claim 41 wherein

- the energy of said correlated detected light is measured; and

- said single signal is produced in dependence on the energy of said correlated detected light.

43. The method as claimed in claim 42 wherein

- said entered radiation is a planar radiation beam;

- avalanche amplified electrons derivable from absorption by a respective transversely separated portion of said planar radiation beam are detected separately by means of a plurality of readout elements as comprised in said electron avalanche detection arrangement; and

- light derivable from absorption by a respective transversely separated portion of said planar radiation beam is detected separately by means of a plurality of individual light detection elements as comprised in said light detection arrangement.